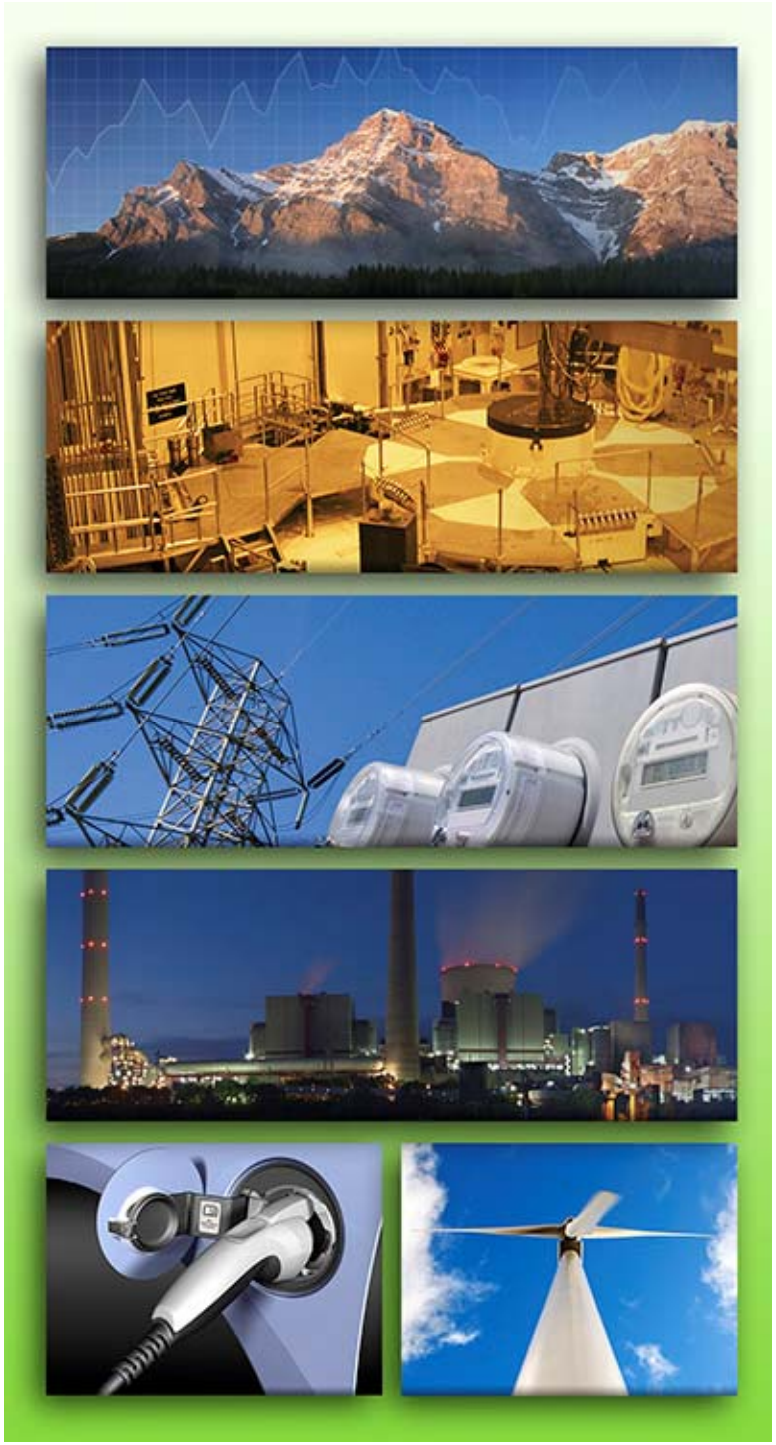

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Integrating Renewables
Role of the Smart Grid

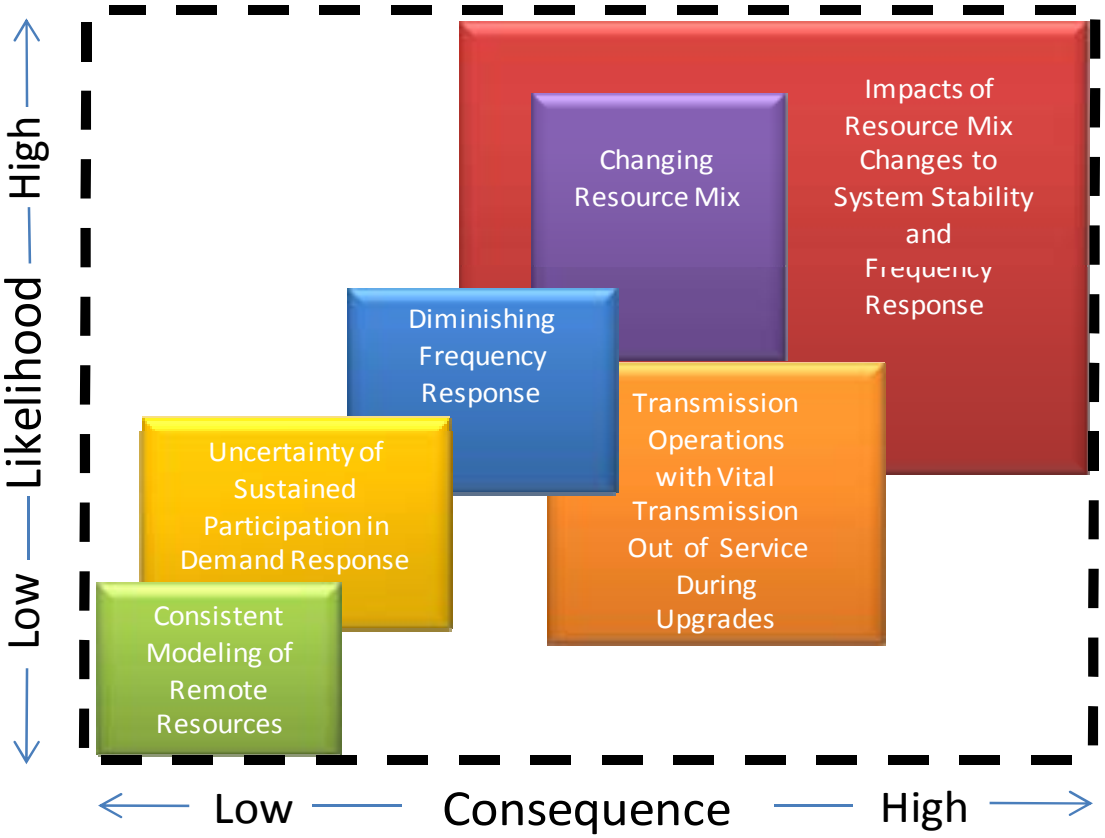
Karen Forsten
Director, Power Delivery & Utilization

Daniel Brooks
Manager, Grid Ops & Planning

2011 NREL ESIF Workshop
October 27, 2011

NERC's Emerging Reliability Trends

Integration of new and emerging technologies is key to successful planning and operations



Source: NERC, "2010 Long-Term Reliability Assessment," October, 2010.

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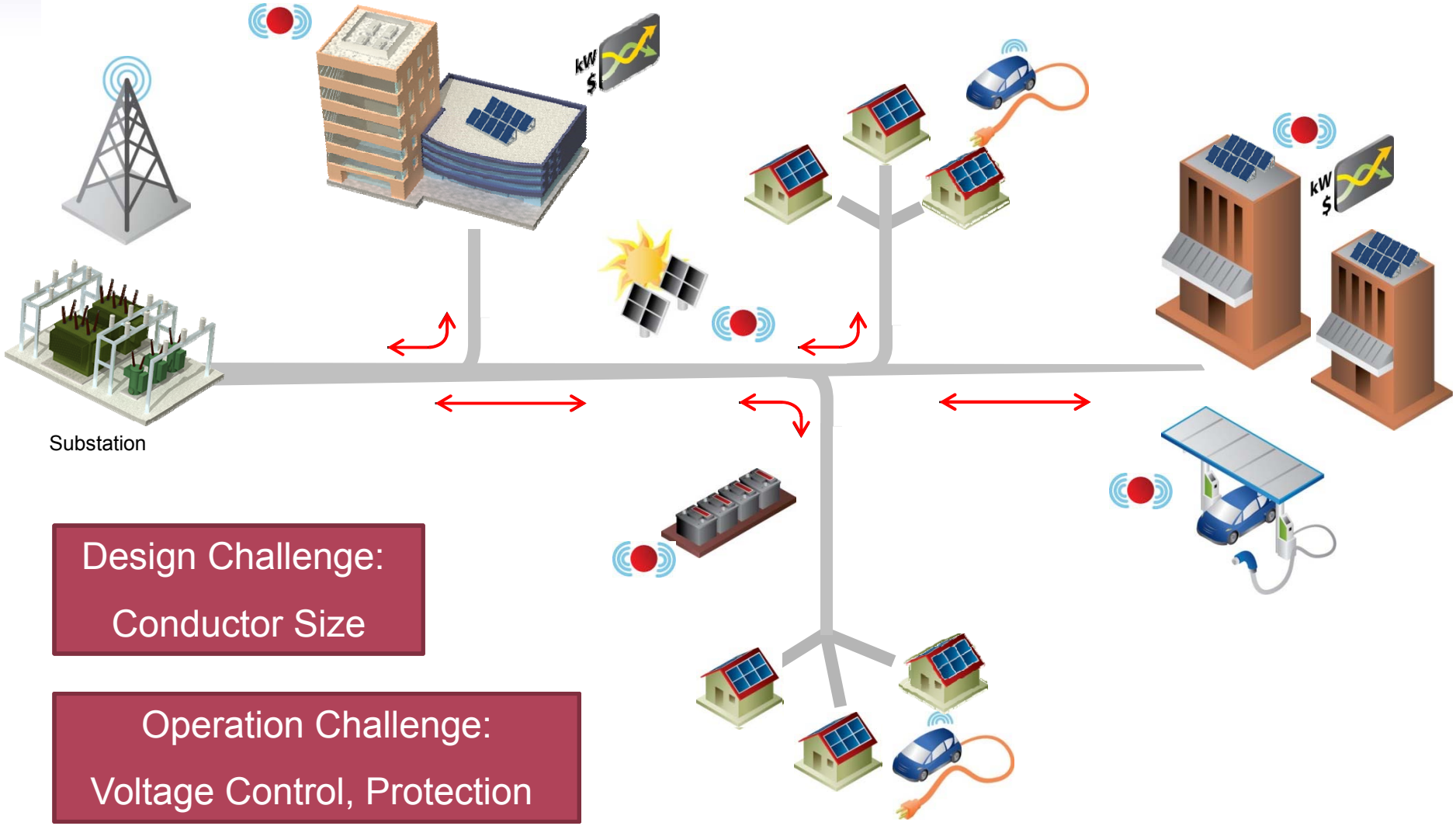
Renewable Integration at All Levels

- Bulk power system
- Distribution system
- Customer system





Distribution System Integration



Design Challenge:
Conductor Size

Operation Challenge:
Voltage Control, Protection

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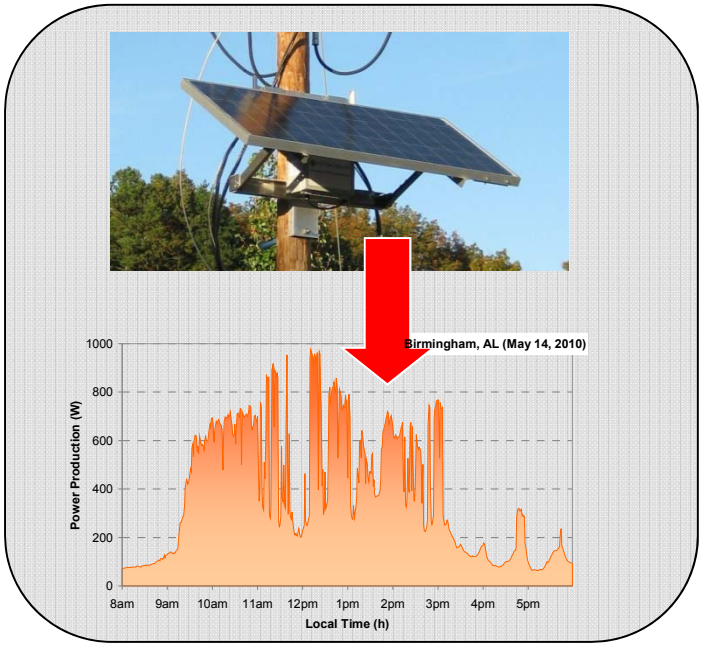
EPRI's Distributed Photovoltaic (DPV) Research

Study on Distributed PV Variability and Distribution System Impacts

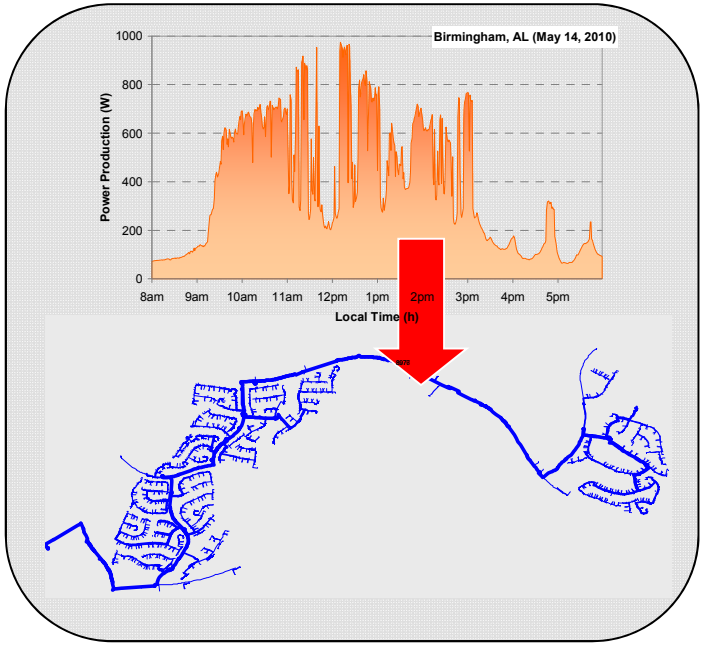
- Industry-wide study
- Launched in mid-2010
- Will continue through 2012
- Looking for 20 utilities, 8 in so far
- 30 to 40 distribution circuits, 26 now
- 250-300 monitoring sites, 180 identified

Two Distinct R&D Projects

PV Output Monitoring



Feeder Impact Analysis



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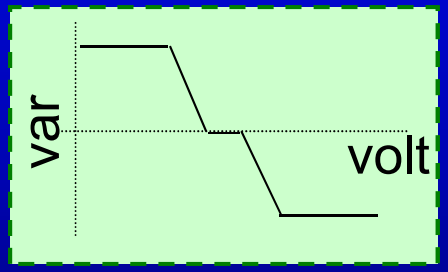
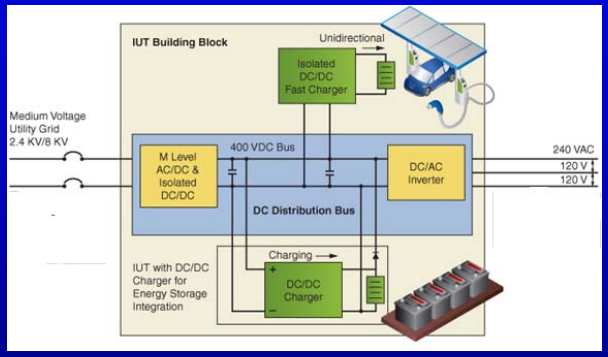
Technologies for Distribution Integration…



Smart Inverters

Distributed Energy Storage



Solid State Transformer

Solar Assisted
EV Charging Station

Integrated with Distribution Management System (DMS)

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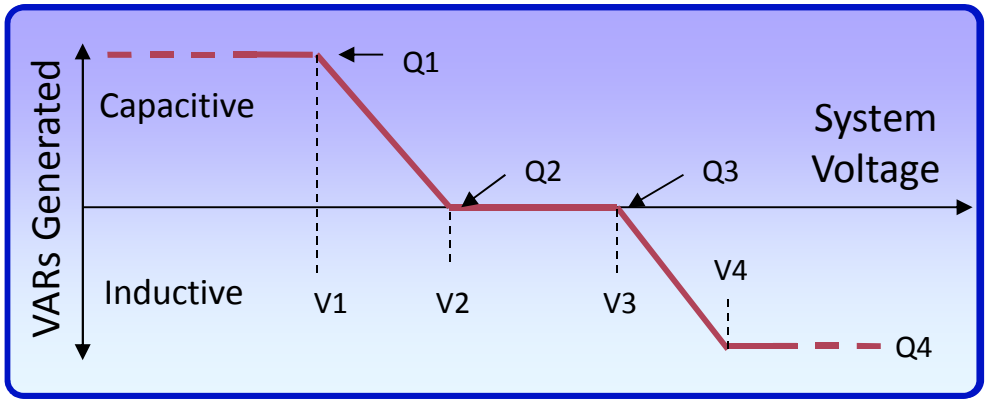
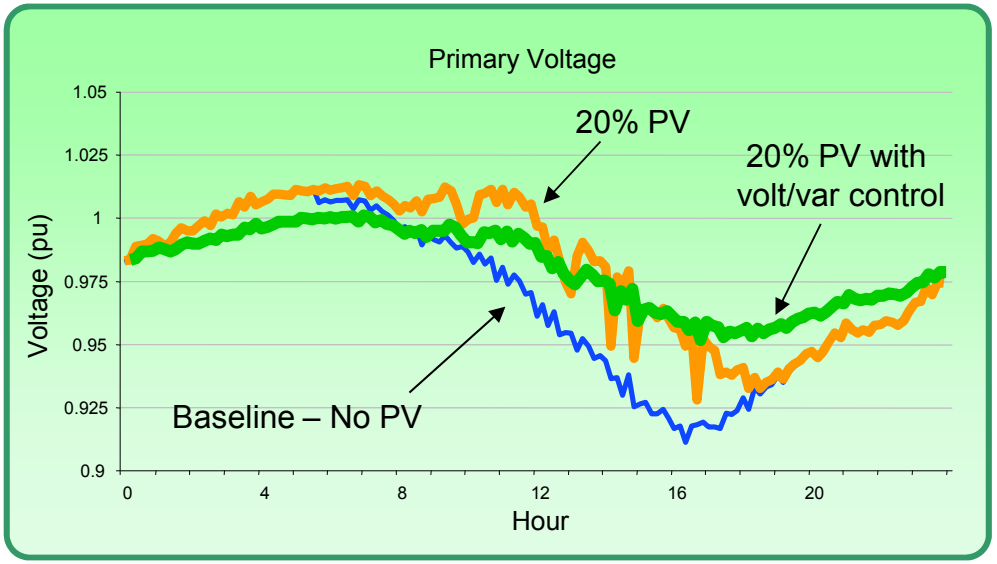
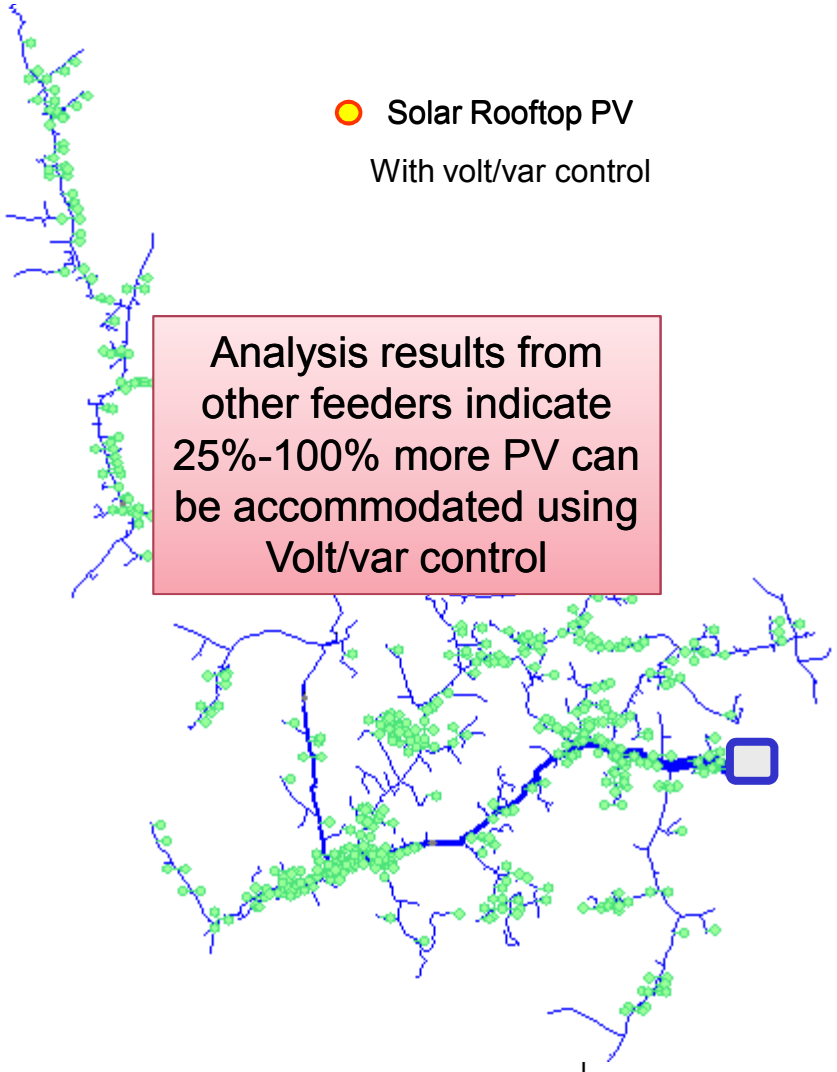
Use of Smart Inverters for Accommodating High-Penetration PV







Analysis results from other feeders indicate 25%-100% more PV can be accommodated using Volt/var control

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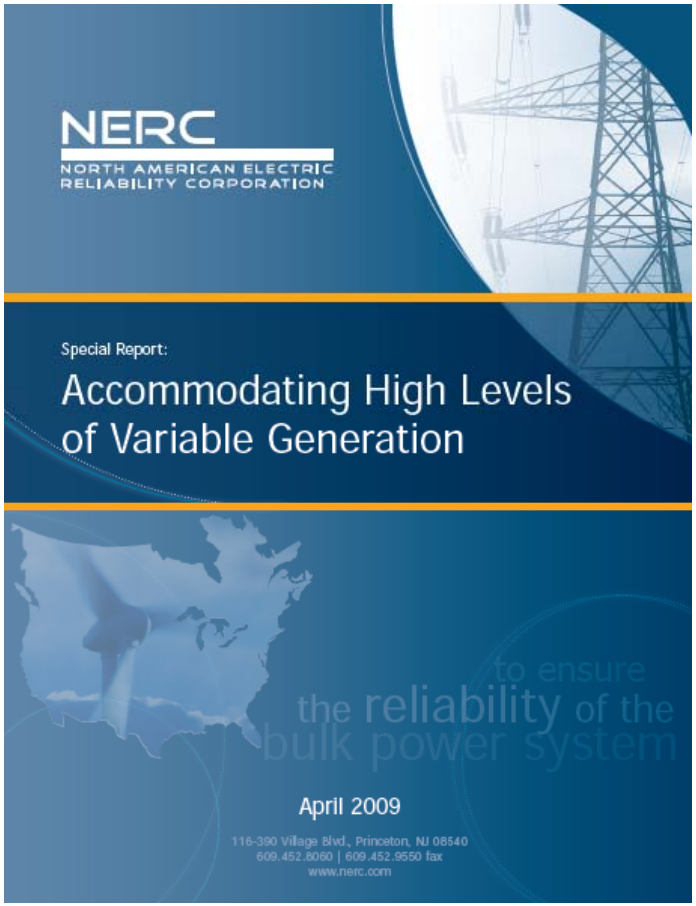
Bulk Power System Integration – a Little More Complicated….

- Transmission Availability
- Flexible Balancing Resource
- Operator Tools for Dispatching Flexible Resource



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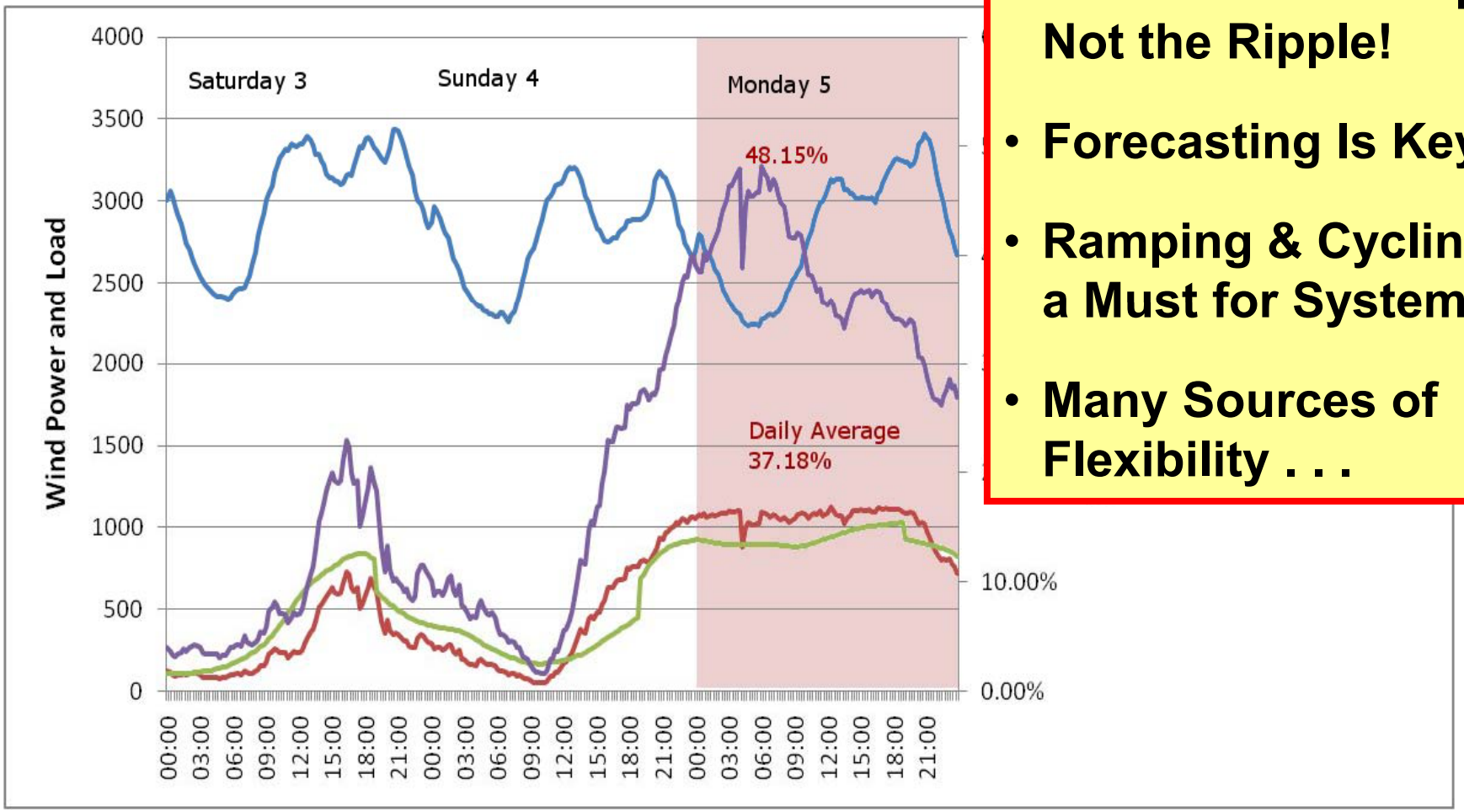
Variability/Uncertainty Increases the Need for System Flexibility



- **It's the Wind Ramp, Not the Ripple!**
- **Forecasting Is Key!**
- **Ramping & Cycling a Must for System!**
- **Many Sources of Flexibility . . .**

Source: Constructed from EIRGRID online data (www.eirgrid.com).

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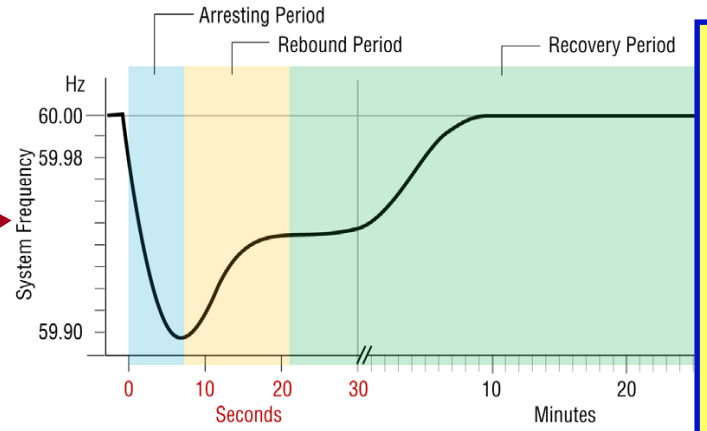
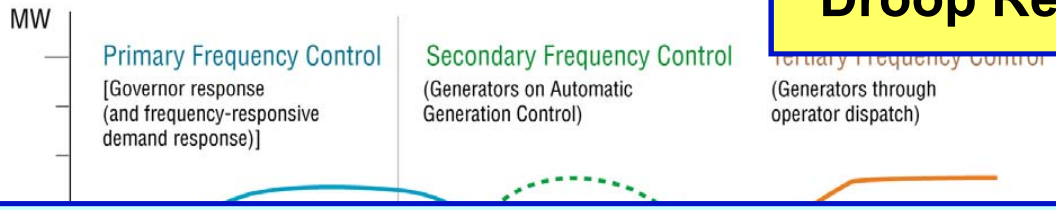
High Levels of Inverter-Based Generation May Impact Frequency Stability

Sudden Loss of Generation



VG Freq Impacts

- **Increase Regulating Reserve small**
- **Potentially Reduce System Inertia & Droop Response**



Inverter-Based Wind & PV can be controlled to emulate Inertia & Governor Response → Determine system needs & validate at scale for actual system disturbances

Graphics Source: LBNL-4142E ***Use of Frequency Response Metrics to Assess the Planning and Operating Requirements for Reliable Integration of Variable Renewable Generation,*** *Prepared for Office of Electric Reliability Federal Energy Regulatory Commission, Dec 2010*

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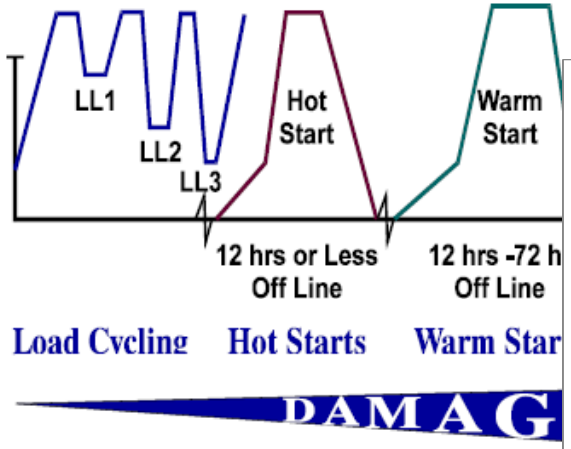
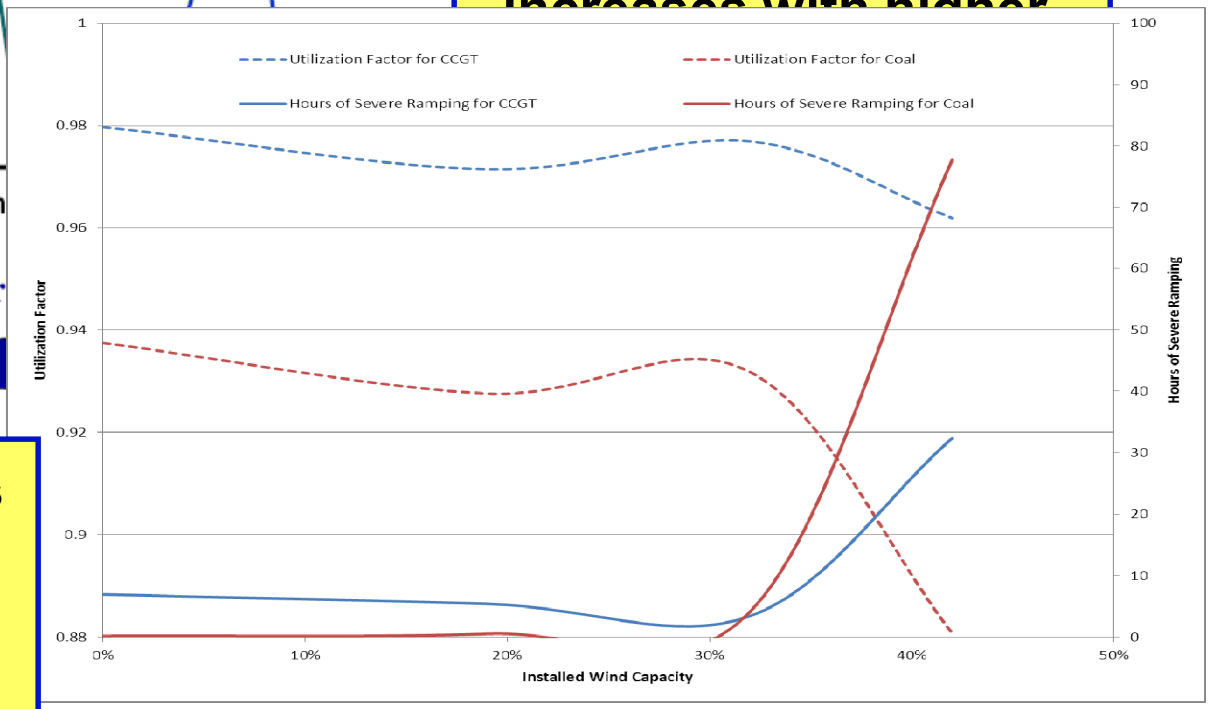
High Levels of VG Will Increase Need for Baseload Generator Cycling



Source: Steve Lefton, Aptech/Intertek

- **Increased cycling affects plant O&M, EFOR, lifetime, efficiency**
- **Changes to operating policies & equipment to deal with VG variability?**

- **Generator Cycling increases with higher**



- *Source: Troy et al, "Baseload cycling on a system with significant wind penetration", IEEE Transactions on Power Systems, Vol. 25, No. 2, May 2010*

Achieving Flexibility: Resources and Markets

Market Flexibility

- **ERCOT**
  - Load as a Resource (LAAR)
- **NYISO**
  - Limited Energy Storage Resource (LESR)
- **NE ISO**
  - Pay for Performance
- **Institution/Market Flexibility**
  - Coordination among BAs
  - Shorter scheduling

Resource Flexibility

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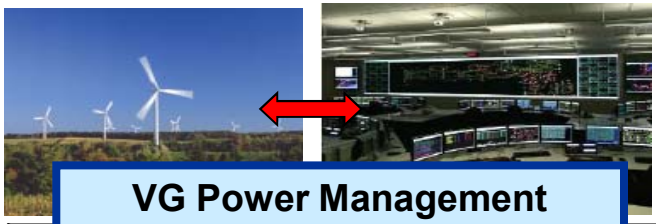
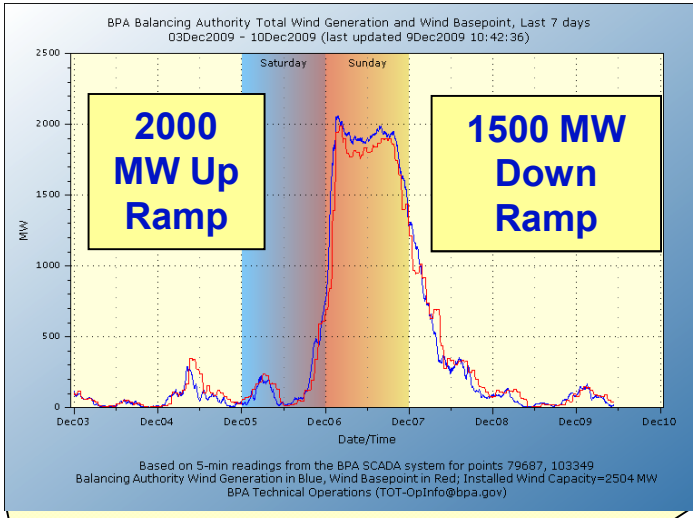
Operator Decision Tools for Variable Generation

Conventional Gen

Emerging Flexible Resources

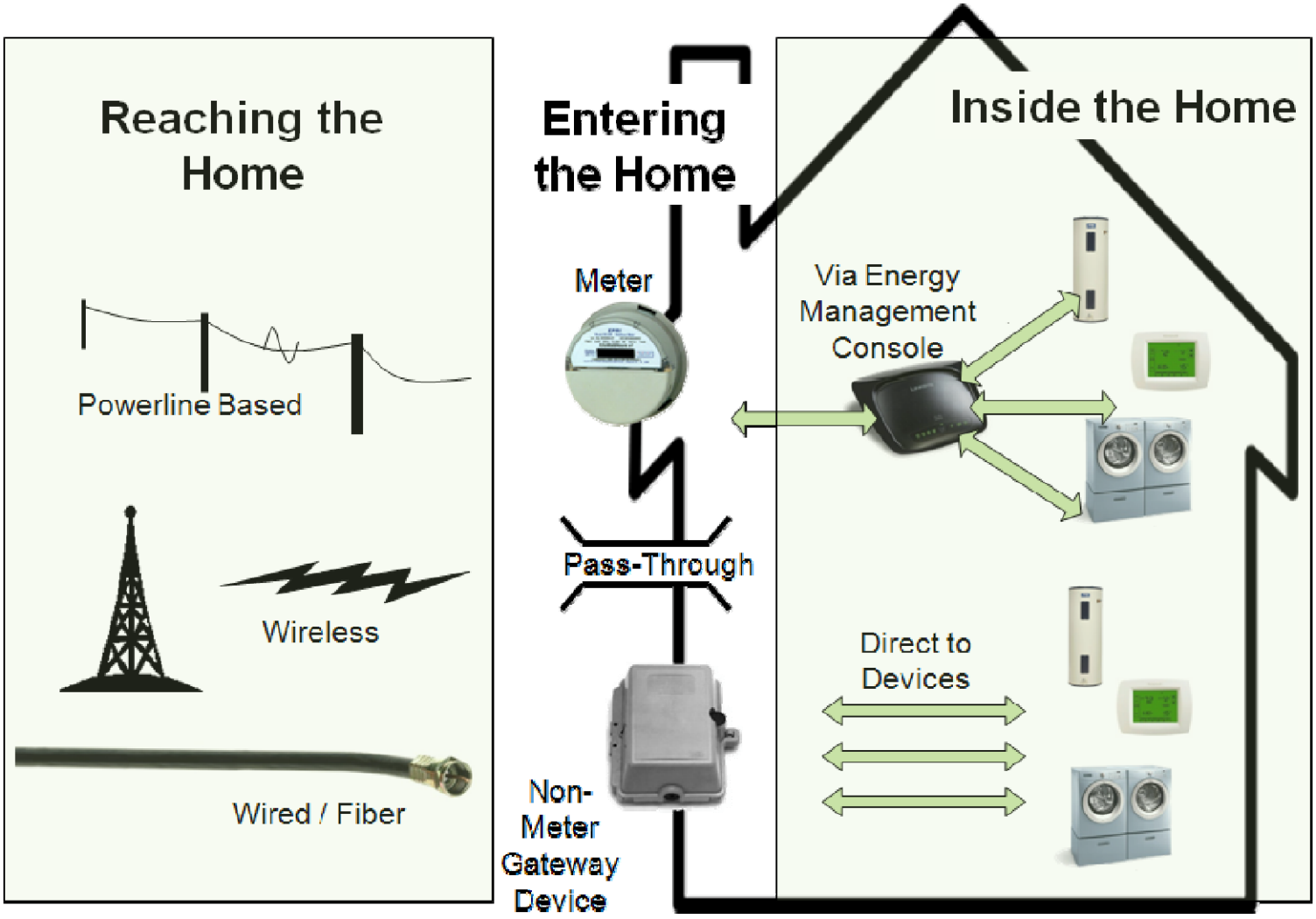


VG Power Management



Source: www.newenglandfutures.com

Extending Demand Response to the Smart Home



Industry Coordination

NERC/FERC

- GMD
- Cyber Security
- Variable Generation
- Flexibility
- Reliability

DOE and National Labs

- NREL including SolarTac
- Smart Grid Demos
- Application Use Cases
- Cyber Security
- Renewable Integration

NIST, IEEE, CIGRE

- Interoperability Standards
- System Modeling
- Common Information Model
- Information Sharing

Leveraging Government and other Industry Efforts

Key to Renewable Integration

- Flexible Resource
- Adequate Distribution and Transmission Lines
- Communication, Control and Operational Support Tools to Ensure Reliability

Significant challenge…but one we can meet!

Together…Shaping the Future of Electricity